

REPORT OF STATE SUPERVISOR OF NATURAL GAS.

OFFICE OF SUPERVISOR OF NATURAL GAS,
INDIANAPOLIS, IND., January 1, 1893. }

To Hon. S. S. Gorby, State Geologist, Indianapolis, Ind. :

SIR—Complying with the provisions of the Statutes of Indiana relating to the supervision of natural gas and the inspection of gas wells and gas plants, I have the honor to submit to you the following detailed report of the transactions of this department for the year 1892.

In this, my second annual report, I have endeavored to show to you the condition of the gas area of Indiana as to the supply of this fuel. How long natural gas will last is the question that is now engaging the attention of a vast number of people; capitalists, manufacturers and private consumers are all alike seeking for a solution of this problem. In order to assist in the solution, as far as lays within my power, I have made careful tests and measurements in all parts of the field, with the results given in my report, and to which I would call the thoughtful attention of all persons who are interested in the preservation of this valuable fuel. The collection of statistics of the manufacturing industries using natural gas has been omitted during the last year, as that comes within the duties of the State Statistician, and may be found in his published reports.

The inspection of plants furnishing gas to private consumers has received my careful attention, as the lives and property of vast numbers of people depend upon the gas plants and machinery being in good condition. In most instances I have found the machinery in fair condition, and comparatively safe. However, as the machinery becomes old and worn more frequent and careful attention will be necessary. I wish to say in this connection that in far too many instances have I found gas plants in charge of wholly incompetent persons, who were profoundly ignorant of the dangerous and powerful agent under their control. I am glad to report, however, that but few accidents have occurred, and these have resulted largely from defective house plumbing.

It is with pleasure that I am able to report to you that the reckless and criminal waste of this most precious fuel that formerly was practiced

in many parts of the field has been almost wholly stopped. While some waste is still practiced in some localities, yet by far the larger number of consumers are advocating the husbanding of this resource in every way possible.

Laws regulating the tubing and packing of wells, as well as the plugging of abandoned wells are needed, and are hereby recommended.

A large oil field is being developed in Blackford, Jay, Wells and Grant counties. Where oil wells are drilled in the neighborhood of gas wells the methods used for obtaining the oil flow are injurious and destructive to the gas wells and the gas territory. It is to be hoped that such methods may be adopted in the production of each of these resources as will not injure the other.

I would recommend that a law be enacted requiring oil wells to use what are known as separators, whereby the gas that is found in such wells may not be wasted, as is done by the present methods.

I take this method of expressing my sincere thanks for the many acts of assistance and for the kind and courteous treatment I have received while in the discharge of my duties.

Respectfully,

E. T. J. JORDAN,
Supervisor of Natural Gas.

NATURAL GAS.

REPORT OF STATE SUPERVISOR.

No form of mineral wealth has awakened as wide-spread interest in our day as natural gas. Certainly there is no other mineral production in the search for which so many people are directly or indirectly engaged. Vast sums of money have been expended in explorations by individuals and private corporations. Propositions to use public money in this way by villages, towns and counties almost always prevail. It may be safely said that millions of people in the Mississippi Valley are actively interested at the present time in the various questions pertaining to this subject. In no other locality has this interest been more manifest than in the gas area of Indiana. In no other place have explorations and developments been carried on more extensively or more rapidly.

The cause of this excitement and interest is not hard to find. It is the money value of the gas that leads to the extraordinary interest that pertains to good territory. The charm that invests a gas field is precisely the same as that which invests a mining district of phenomenal richness.

The great advantages of natural gas, in addition to the luxury it affords as a domestic fuel, are found in the support which it gives to different manufacturing industries. It is so happily adapted to certain lines of manufacturing, that competition, without it, is almost out of the question.

Its presence in such large quantities in Indiana has invited and stimulated manufacturing to a wonderful degree. Not less than three hundred manufactories of various sorts have been located and put in operation as a direct result of the discovery and development of natural gas.

Many of them are wonderful for their magnitude, an example of which is the DePauw Plate Glass Works at Alexandria, which is said to be the largest of its kind in the world. Millions of dollars are invested in these manufactories with the almost certain hope of profitable returns. In addition to the direct value of a gas field, alert business men have been quick to recognize the fact that no other element in the list of natural advantages of a town can be made to exert half the attractive power that the possession of a good supply of the new fuel can give. Real estate speculation has sprung up in many of the favored towns of Indiana during the last few years based wholly upon the presence of this new

element. As a result of the building up of the immense manufacturing interests which I have noted above, together with the real estate speculation which has been induced, a wonderful growth of the villages and towns in this favored territory has been observed. Places that a few years ago contained only the country store, the postoffice and the village blacksmith shop have developed into large towns, and towns have grown into thriving cities. In many cases this real estate speculation has been of the most violent and unreasonable sort. In these places the boom spirit ran wild, and prices were advanced beyond reason or justification. To the influence of this speculative spirit I attribute, in a large degree, the lack of economy in the consumption of gas, and the criminal waste that has been practiced. A slow growth, long continued, is far better than quick returns accomplished by the exhaustion of the natural resources. He is a false economist and an enemy to the highest interests of his town or community, who is willing, for the sake of present gains, to sacrifice the resources upon which his town depends.

Natural gas is so admirably adapted in all its ways as a household fuel that it ought to be kept by every community that obtains it largely for this use. The factories may well enough forge along on the old system. The comfort of life for the many is certainly to be preferred to the undue business advantage of the few.

CONDITION OF THE FIELD.

Is the supply of natural gas failing? In view of the great advantages that are being derived from the use of this fuel within the area under consideration, this question assumes great importance. It may not be possible to give a definite answer to this question, as there are so many and varied conditions to be considered. The conditions necessary to the production of this fuel are area, thickness, density, initial pressure and structural arrangements. These conditions have been described in my report to the State Geologist, made January 1, 1892, and published in the Seventeenth Geological Report of Indiana. I do not care, in this connection, to repeat what is there published. In order that an approximate answer to the above question may be had, I will consider the initial pressure alone. This is commonly known as the rock pressure, but I consider the term misleading, hence I will use that which I consider the better term, initial pressure. This, I believe, will give the best idea of the present condition of the supply within the area under consideration. It is admitted by all scientists, as well as by others who have had practical experience in the development and handling of natural gas, that any material reduction in the initial pressure indicates a corresponding, if not an increased diminution in the volume of the supply. The original initial pressure within the Indiana field was 325 pounds to the square inch.

This pressure is still found in some of the new wells in localities in which the consumption has been unimportant in amount. The following is the results of careful tests made by me in different localities within the field. The measurements were made in most cases with a mercury gauge or with carefully tested spring gauges. The showings are not as favorable as could be desired, but I vouch for their correctness, and give them to show the present condition of the field.

GREENFIELD, HANCOCK COUNTY.

GREENFIELD NATURAL GAS COMPANY.

Wells Tested June 6, 1892.

Well No. 1—Initial pressure, $102\frac{1}{2}$ pounds to the square inch. This well was drilled in May, 1886, and showed at that time the original pressure of the field. The original volume was 5,000,000 cubic feet in twenty-four hours. The present yield is 1,266,000 cubic feet per day.

Citizen's Well—Initial pressure, 106 pounds; present volume, 1,266,000 cubic feet.

Well No. 4—Present volume, 110,880 cubic feet.

City Well—Initial pressure, 60 pounds. The volume was not ascertained.

Gooding Well, No. 1—Initial pressure, 170 pounds.

Gooding Well, No. 2—Initial pressure, 215 pounds; volume, 400,000 cubic feet.

Gooding Well, No. 3—Initial pressure, 225 pounds; volume, 1,266,000 cubic feet.

Baldwin Well, No. 2—Initial pressure, 170 pounds; volume, 414,000 cubic feet.

PEOPLE'S NATURAL GAS COMPANY.

Wells Tested June 14, 1892.

Well No. 1—Initial pressure, 120 pounds; volume, in $1\frac{1}{2}$ -inch pipe, 394,540 cubic feet.

Well No. 2 (also called the New well)—Initial pressure, $142\frac{1}{2}$ pounds; volume, 313,660 cubic feet.

Well No. 3—Initial pressure, 90 pounds; volume, 350,670 cubic feet.

East Well, No. 4—Initial pressure, 125 pounds; volume, 246,135 cubic feet.

Henry Well, No. 5—Initial pressure, 190 pounds; volume, 221,160 cubic feet.

SOUTHERN INDIANA GAS COMPANY.

Wells Tested June 28, 1892.

Slifer Well, No. 1—Exhausted.

J. Slifer Well, No. 2—Initial pressure, 250 pounds; volume, 271,630 cubic feet.

J New Well, No. 3—Initial pressure, 230 pounds; volume, 700,000 cubic feet.

Bowen Well, No. 4—Initial pressure, 252 pounds; volume, 700,000 cubic feet.

Martindale Well, No. 5—Initial pressure, 230 pounds; volume, 2,357,100 cubic feet.

Boyd Well, No. 6—Initial pressure, 200 pounds; volume, 300,000 cubic feet.

Glasscock Well, No. 7—Initial pressure, 225 pounds; volume, 700,000 cubic feet.

Baldwin Well, No. 8—Exhausted.

Marsh Well, No. 1—Initial pressure, 230 pounds.

Marsh Well, No. 2—Initial pressure, 200 pounds; volume, 300,000 cubic feet.

In taking these pressures it required from one to six minutes to reach the pressures given. The wells of the first two companies given are located within a radius of one and one-half miles from the court house, in the town of Greenfield. The wells of the last company given are located from one to four miles east and north of the town of Greenfield. I have been particular in giving so many wells in order to show the variations both in pressure and volume that is observed in the same locality. These wells have been in use from two to five years, and all of them show more or less of salt water. Within the area in which these wells are located are a number of other wells belonging to private individuals and manufactories. These wells will average with the wells given above, with the exception of Well No. 1, belonging to the nail works, which showed an initial pressure of 250 pounds when drilled in 1891, and when tested June 28, 1892, the initial pressure was 140 pounds, with a volume of 3,995,000 cubic feet. This well showed a large quantity of salt water, which appeared to affect the initial pressure, but not the volume.

MARION, GRANT COUNTY.

Wells Tested July 7, 1892.

Charles Well, No. 4—Drilled July, 1887. Initial pressure, 220 pounds; volume, 1,895,000 cubic feet.

Bradford Well, No. 4—Initial pressure, 240 pounds; volume, 1,465,000 cubic feet.

Crosby Well—Initial pressure, 225 pounds; volume, 2,020,000 cubic feet.

Mississinewa, No. 9—Initial pressure, 290 pounds; volume, 3,250,000 cubic feet.

Soldiers' Home Well—Initial pressure, 308 pounds; volume, 4,550,000 cubic feet.

Soldiers' Home New Well—Initial pressure, 315 pounds.

The wells given above are probably above the average for this locality. Many of the other wells are filling up with salt water, and some have been abandoned, having become worthless. A number of failures to obtain gas in this locality have been made within the last year. It is but just to state, however, that these failures have all been confined to one part of the locality. There appears to be a syncline in the rock, in which no gas is found, owing to its density and the presence of salt water.

JONESBORO, GRANT COUNTY.

JONESBORO MINING COMPANY.

Wells Tested September 6, 1892.

Well No. 1—Drilled in April, 1887. •

It is claimed for this well that the original pressure was 330 pounds, and according to a measurement made by Prof. Orton, State Geologist of Ohio, that its original volume was 5,500,000 cubic feet in twenty-four hours.

This well has been in constant use since it was drilled, supplying an average of 350 fires, together with two or three small factories. When I tested this well it was supplying 400 fires. With this consumption the initial pressure was 305 pounds. I had no opportunity to measure the volume, but do not think that there has been any great falling off from its original measurement. The gas obtained from this well is perfectly dry.

HARRISBURG GAS AND MINING COMPANY.

Well No. 1—Drilled April, 1889. Initial pressure, 310 pounds. This well was drilled fifty-two feet in the Trenton limestone, and is perfectly dry.

GAS CITY LAND COMPANY.

Well No. 2—This is a new well. Initial pressure, 310 pounds.

THOMPSON & COMPANY.

Well No. 1—This is a recent well. Initial pressure, 310 pounds.

Coleman Well—Initial pressure, 300 pounds.

This well is three and one-half years old, and was supplying four large boilers and twenty-five stoves when the measurement was made. The wells in this locality have penetrated the Trenton limestone from forty to sixty feet, and all show dry gas.

KOKOMO, HOWARD COUNTY.

The Kokomo Gas Company has its fourteen wells, located from two to seven miles south of the city. The initial pressure varies from 240 to 300 pounds.

The wells that are located within and immediately around the city are practically valueless, having filled up with salt water. Kokomo, however, is well supplied with gas, as in addition to what is furnished by the above company, the Chicago Gas Company has recently laid an eight-inch line from their wells near Greentown.

This company owns a large amount of the best producing gas territory in the State, upon which they have drilled a great number of wells. With the facilities at their command they, alone, can furnish gas in quantities to supply the needs of this city. Taking the capacities of these two companies, together with two other private lines which are owned and operated by some of the manufactories, and extend from four to eight miles into the country, this city is as well supplied with this valuable fuel as any town in the State.

NOBLESVILLE, HAMILTON COUNTY.

The wells in this locality show an initial pressure varying from 150 to 250 pounds, and many of them are filling up with salt water. Separators are used on many of them to keep the water out of the lines. Some have been abandoned as worthless. Among the abandoned ones is the old "Wainright Wonder." This was one of the first wells drilled in the locality, and originally one of the largest producing wells in the State. It was a monster among gas wells, and was visited by thousands of people from far and near curious to see the wonderful exhibition of its power. For weeks and months it was allowed to stand open, belching forth its millions of cubic feet of valuable fuel. This policy soon brought the inevitable result. The draft was so great that its initial pressure was so much reduced that salt water was introduced and steadily increased until the "Wonder" was rendered worthless.

ANDERSON, MADISON COUNTY.

In this locality the greatest initial pressure obtained in my measurements was 245 pounds. This was in wells recently drilled, and located two miles from the city. The territory within the limits of the city proper is practically exhausted, and filled with salt water. As a proof of this a well drilled by the Commissioners of the County in the jail yard and near the center of the city proved a total failure.

The location of this well in close proximity to some of the first wells drilled in that locality, and which had formerly been large producers of gas. The citizens are beginning to realize the exhausted condition of their immediate territory and are making preparations to extend pipe lines into the country places in order to obtain a supply of gas sufficient for the great and growing needs of their city. Of this reserved territory, it may be said that there is still a large amount within the country, and within easy reach. When this reserve, which has not been touched except by a few farmers' wells, is made available, and economy is used in its consumption, then the comfort and prosperity of the city is assured for sometime to come.

ALEXANDRIA, MADISON COUNTY.

Tests Made April 28, 1892.

The wells in this locality made as good a showing as any in the whole field. This is accounted for on the grounds that the draft on this territory has been to the present time comparatively trifling, and that the condition of thickness of the gas bearing portions of the Trenton limestone is as favorable here as in any other portion of the field. In the wells located here the drill has penetrated the Trenton limestone to the depth of fifty feet without encountering salt water, and with a constantly increasing flow of gas.

Plate Glass Well No. 1.—Initial pressure, 325 pounds; volume, 7,014,000 cubic feet.

In this well there was a small consumption going on when the measurements were taken, so that the above figures are below the actual volume.

Plate Glass Well No. 3.—This was a new well, and had not been tubed and packed. The flowing pressure from a five and five-eighths inch casing pipe, indicated a volume of 12,435,000 cubic feet. When properly packed and tubed with three-inch tubing, this showing of volume would be reduced to probably nine or ten million cubic feet. I had no means for inclosing the well, consequently a measurement of the initial pressure could not be taken. I have since been informed that this well showed 325 pounds after it had been tubed and packed.

A well belonging to the Alexandria Land and Gas Company, which I tested while supplying some forty or fifty stoves, showed an initial pressure of 325 pounds, and a volume of 6,248,000 cubic feet.

The original well of this town, which is five years old, and which has been in constant use, although not drafted heavily, showed an initial pressure of 300 pounds, and with a very little diminution of volume.

ELWOOD, MADISON COUNTY.

Test Made April 29, 1892.

In this locality, notwithstanding the heavy draft that has been made on this territory by the domestic consumption of a town that has grown to a city of four thousand inhabitants, together with a number of very extensive manufactories, the wells make a remarkably good showing. The new wells show an initial pressure of 325 pounds and the old ones did not go below 250 pounds.

DeHority Well, No. 5—This is a recent well and is located within seven hundred feet of one of the oldest wells. Initial pressure, 325 pounds; volume, 6,738,000 cubic feet. In this locality the drill, in some of the wells, was driven into the Trenton limestone to the depth of forty-five feet, and obtained a constantly increasing flow of perfectly dry gas. Salt water, however, is now encroaching on some of the older wells.

CARMEL, HAMILTON COUNTY.

Tested September 1, 1892.

Well No. 1—Drilled in 1888. Initial pressure in 14 minutes, 240 pounds; volume less than 250,000 cubic feet.

Well No. 2—Drilled in 1888. Initial pressure in 8 minutes, 225 pounds; volume less than 250,000 cubic feet.

Well No. 3—Drilled in 1891. Initial pressure in 2 minutes, 297 pounds; volume less than 1,140,500 cubic feet.

These wells only penetrate the Trenton limestone to the depth of eight feet and were not "shot!"

The salt water in this territory lies so near the top of the rock that wells drilled to a greater depth than those above mentioned, or that are "shot," immediately fill up with water and are worthless.

DUNKIRK, JAY COUNTY.

Inspected August 25, 1892.

Well No. 1—Showed an initial pressure of 262 pounds.

Well No. 2—Initial pressure, 292 pounds.

These wells are old and have been heavily drafted. I had no means for measuring the volume, as the wells could not be disconnected from the line.

ENTERPRIZE WINDOW GLASS COMPANY.

Well No. 1—This is a new well and showed an initial pressure of 310 pounds; volume in 3-inch tube, 6,738,000 cubic feet.

Vance Well—This is a recent well and showed an initial pressure of 290 pounds; volume in 3-inch tube, 7,014,000 cubic feet.

WESTFIELD, HAMILTON COUNTY.

WESTFIELD GAS AND MINING COMPANY.

This company owns three wells which are located three miles southeast of town. These wells show a pressure of 250 pounds. Originally the same wells showed an initial pressure of 325 pounds. So far, no showing of salt water has been discovered.

SUMMITVILLE, MADISON COUNTY.

SUMMITVILLE, MINING COMPANY.

Inspected November 8, 1892.

Well No. 1—Four years old. Back pressure 200 pounds. This showing was made while the well was supplying five hundred fires, which could not be disconnected.

KNIGHTSTOWN, HENRY COUNTY.

Reported November 2, 1892.

The new wells in this locality show an initial pressure of 245 pounds; the old wells 200 pounds. The Knightstown Gas Company have abandoned five wells, they having filled up with salt water.

The Soldiers' Orphans' Home, which is located in the immediate neighborhood, has abandoned four wells for the same reason. The volume found in the wells of this locality varies from one-half million to two million feet.

ARCADIA, HAMILTON COUNTY.

Inspected November 30, 1892.

This town has two wells which gives back pressure of 170 pounds, while supplying a consumption of three hundred and fifty stoves and one large brick kiln, one flouring mill, one tile factory, one elevator, one saw-mill, one planing mill and one harness factory.

CICERO, HAMILTON COUNTY.

Inspected November 30, 1892.

Well No. 1—Initial pressure, 240 pounds.

Well No. 2—Initial pressure, 242 pounds.

A well recently drilled for a glass factory at this place proved a failure.

Tests were made during the year at Frankton, Albany, Red Key, Montpelier and other points, but I consider those given above sufficient to show the condition of the field in regard to the initial pressure. The original normal pressure in this field was 325 pounds to the square inch. The tests given above show in many places a reduction from the original pressure. That this reduction is greatest in localities that have had the largest consumption is evident to every observer. With this reduction in pressure there has been a corresponding reduction in volume. When the decrease in pressure has reached certain points, which differ in different localities, salt water has been introduced, which tends to hasten the end, not only of the individual well, but of the immediate surrounding territory. That there will be ultimate exhaustion is now no longer denied. That this end has been hastened by the reckless extravagance and criminal waste that has been practiced is also admitted.

EXHAUSTION OF GAS.

Under this head I can not do better than to quote from the report of the Superintendent of the eleventh census of the United States, as given under the head of mineral industries:

“That the supply of natural gas is limited and will ultimately be exhausted has never been questioned. When the great reservoirs of Western Pennsylvania, Northwestern Ohio and Eastern Indiana were first struck the supply was so bountiful that many were led to believe that it was practically inexhaustible; at least there is no other sensible explanation of the wastefulness with which it was used at first or the readiness with which manufacturing plants were located in the natural

gas regions, away from cheap supplies or other fuel. But even while these parties by their actions expressed their confidence in the continuance of the supply of gas at least for the near future, they were ready to concede that ultimately it would be exhausted. The question at issue was, How long could the supply be depended upon?

In the early history of natural gas, say in 1884 and 1885, there were various theories advanced as to the origin of it. The belief as to the continuance of the supply of gas depended somewhat upon which of these theories was accepted. They were generally known as the storage theory and the continuous production theory. The advocates of the storage theory asserted that the supply would be exhausted when the gas in the storage reservoirs had been consumed. The advocates of the continuous production theory, while they claimed that the supply was being added to by production going on continuously at a point below the storage reservoirs, yet conceded that it was not probable that the supply could be maintained in the face of the enormous consumption by any probable rate of production that is at present going on in the earth's interior. The advocates of the latter theory, of course, held that as production was continuous, the day of exhaustion was further in the future than was admitted by the advocates of the storage theory, and that even when the vast store-houses that existed in the earth's crust prior to their being tapped were exhausted, production would still continue, and gas be supplied, though in smaller quantities.

The statistics of the census year 1889 show that the period of the exhaustion of the supply had been entered upon, and that the day had passed when this wonderful fuel could be used so wastefully as it had, been in many operations, and in the very near future it would be possible to use it only for those purposes which could afford to pay comparatively high rates for the convenience of having such a fuel, or at points where the demand does not bear such a relation to the supply as it does in Western Pennsylvania, and the other great gas producing districts. It is probable that at many points it will continue to be used for years for domestic purposes, but its use in large establishments, demanding greater quantities of fuel, is, in many sections of the country, a thing of the past. These works can make artificial fuel gas by some one of the many known processes, at less figures in many instances, than natural gas can be furnished. This is especially true at Pittsburgh, where there is such a demand for gas for domestic purposes, and by other small consumers, that the natural gas companies are refusing to continue to supply large industrial establishments except at a price that is prohibitory. Hence the use of natural gas in large industrial establishments in the Pittsburgh district and others, is falling off, and these works are returning to solid fuel, or using artificially prepared gas. Some interesting facts regarding the exhaustion of gas in certain fields have been observed. It is found as a

rule, for example, that shallow wells, 200 to even 1,000 feet deep, whatever may be the pressure or supply when first struck, give out much sooner than what are known as deep wells. In certain fields the supply at individual wells is soon exhausted, and the amount furnished by new wells, when first bored, is a constantly decreasing quantity, as compared with that supplied by the earlier wells. In other districts the life of wells is longer, but the earlier wells are now quite weak or entirely exhausted, and new wells sunk do not produce any such amount of gas as those at first drilled. In other districts, as the gas is exhausted, the salt water is finding its way into the wells drilled nearest to the borders of the pool in which the gas is found. Many wells in this way have been drowned out; while other wells in the district are still producing. In no district of any importance do the "great gassers" supply gas either at the same pressure or with same volume as when first struck.

The gas areas of the country are evidently small, scattered irregularly, and hemmed in by water areas and oil areas, and, if the theory of Prof. Lesley is to be adopted, they are not absolutely stationary, but shift their positions slightly as a result in part of the pressure of these water and oil areas and in part of other seismic causes. This shifting of gas areas Prof. Lesley suggests will be comparatively rapid in the direction of the working wells as the stock of gas is drawn off, and what was at first a gas flow will become changed to an oil or water field.

WASTE OF GAS.

I am glad to be able to report that as the consumer begins to realize that their stock of precious fuel is limited in quantity they are beginning to husband it as best they can. Much of the reckless waste that has heretofore been practiced has been stopped. Wells, when first drilled, are not allowed to stand open for days and weeks as was formerly the custom. By a law of the State owners and contractors are compelled to pack their wells as speedily as the work can be done, and a failure to do so renders them liable to heavy penalties. Many other reckless extravagancies have been abolished, and consumers are being thoroughly aroused to the necessities of the occasion.

THE TRANSPORTATION OF NATURAL GAS.

Since the first pipe line was laid, some twenty years ago, for the conveyance of natural gas from wells a few miles distant, and especially within the last eight years, large sums of money have been expended in this line of work, and a great deal of valuable information has been gained. The conveying of enormous volumes of gas from wells that in

some instances have an initial pressure of from 300 to 700 pounds to the square inch, in pipe lines, which sometimes reach well nigh a hundred miles in length, and its perfect distribution throughout the streets and dwellings of a great city for every use to which fuel is applied, gives rise to an almost new branch of mechanical engineering. Serious difficulties have been overcome and threatened dangers have been obviated, and the safe and successful introduction of the new fuel has been fully accomplished.

The pipes through which gas is transported and distributed are made of lap-welded wrought iron, or of steel, when used in the high pressure portions of the lines. Cast-iron pipes of large size have been used of late on the low pressure sides of pipe lines where the pressure does not exceed ten or fifteen pounds to the square inch. Cast iron is not considered safe to be used in those portions of the line that are exposed to the full pressure of strong wells, but since the initial pressure in some of the gas areas of Pennsylvania and Ohio have fallen so materially, cast iron lines have been laid in a few instances, for the entire distance, from the wells to the points of consumption.

Naturally the sizes of the pipe lines vary greatly according to the demand made upon them. In the Indiana field they range from one inch to twelve inches in diameter. The usual sizes range between four and eight inches. The smaller sizes, one, two and three inches, are used in short distances and where small supplies are required. In those localities having feeble wells and where the pressure has materially lessened, a great advantage can be derived in having pipes of large diameter. The capacities of pipes vary with the squares of their diameter; for example: A six-inch pipe carries two and one-fourth times as much gas as a four-inch pipe. An eight-inch pipe carries four times as much gas as a four-inch pipe. From a pipe four times as long as another, one-half as much gas can be obtained, other things being equal.

From a pipe one-fourth as long as another, twice as much gas can be discharged, other things being equal.

Pipe lines should always be laid below the reach of frost. More or less water finds access to the line. The expansion of the gas, as it reaches the surface, considerably reduces the temperature of the pipe; and consequently it is an easy matter for any water in the line to freeze, if low atmospheric temperature can affect it. However, in the gas area of Indiana many of the smaller companies, and especially what are known as "Farmer Companies," the pipes are laid on the surface of the ground. This is done to save expense, and heaters are placed at intervals along the lines which prevent freezing.

The danger of introducing the enormous pressure of the wells into towns has been overcome by the use of regulators. These are of various patterns and are capable of controlling the flow of the strongest wells.

By means of the regulators the pressure is reduced to any required amount at any point on the line.

As the supply of gas weakens from natural causes, it often happens that there is no longer force enough in the wells to send even the gas that is produced to its destination. When this is the case it will be necessary to supplement the pressure from the wells by the use of compressors or blowers, along the line. This is done by the use of pumps of the same sort as those employed in forcing air into deep mines. This system is now in successful use in bringing natural gas to Louisville, Ky., and Chicago, Ill. As the gas weakens, all pipe lines of any length will have to reinforce the pressure in this way. The pressure in any pipe line in Indiana is limited by law to three hundred pounds to the square inch.

METERS.

On this subject I will quote Professor Orton. In his report on the "Petroleum and Natural Gas of Kentucky," he says: "There is a growing disposition to introduce meters into all the distributing systems of the natural gas companies. As is well known, when natural gas was first brought into use the supply was abundant, and the most reckless waste was tolerated. Five years ago, a calculation showed that 60,000,000 feet per day were burning from waste pipes connected with the Pittsburgh supply alone. The prices for gas at that time were fixed for the use required; as, for example, so much for every ton of iron or steel worked with gas; so much for glass pot; so much for a steam boiler, with and sometimes without regard to its horse power, and on the same basis prices were fixed for stoves, grates and furnaces. No inducement was offered to the users of gas to adopt economical methods. As the use of gas has rapidly extended, while at the same time the original supply has been rapidly reduced, a new state of things has been brought about, and the gas companies are now using all means in their power to effect an economical consumption of fuel, and to avoid all forms of waste. Nothing works more efficiently in this direction than the introduction of meters.

"Meters are now constructed so as to be adapted to every demand of the new fuel, and wherever natural gas is introduced it ought to be sold, from the outset, by measured volume."

In regard to the piping of natural gas it is to the decided advantage of every town that is fortunate enough to find a supply to use only the best methods in introducing it. All the problems of a safe and economical distribution have been solved by the leading companies that are engaged in this work, and it is a great mistake on the part of any town to fail to avail itself of this experience.

There are, it is true, many parties ready to underbid the rates of the great companies; but the money saved by the substitution of inferior and unskilled work will, in all probability, be lost several times over in attempting to remedy the defects of a line laid in such a way. Indeed, the defects are generally irremediable, and lines of this sort are sure to be sources of constant annoyance, danger and waste. To provide supervision of the entire work by piping and distributing the gas by a thoroughly skilled and experienced pipe line engineer, is the very least that can be asked of any town into which natural gas is being introduced.

ORIGIN OF NATURAL GAS.

In regard to the origin of natural gas a great deal has been said. Many and various theories have been advanced to account for this wonderful product, each of which has been supported by more or less show of reason. Each of these theories has had its supporters and its day. Some of them have had some foundation to build upon, while others have been absurd and totally false. Scientists and men who have had practical experience now agree as to the source and origin of this fuel. Without taking up and discussing the different theories that have been advanced, I will give the one that is now practically accepted by everybody who is interested in this product. I do this in this place for the benefit of those who have not had the advantage of the writers on this subject. In so doing I do not claim anything new or original for myself, but shall aim to give the theory that is now generally conceded.

It is not necessary, and indeed it would be impossible to consider the origin of natural gas and petroleum separately. They have a common history. They are produced from the same source, accumulated by similar agencies, and stored in the same reservoirs. In order of formation, petroleum is probably first, and as it is more complex in composition it is thus nearer to the organic world from which it is derived. Gas is the same substance nearer to the simplicity of inorganic compounds. There is no process known by which gas can be made into oil, but the generation of petroleum into gaseous products is seen to be constantly carried on in nature, and it is also effected artificially.

Neither petroleum nor gas is ever found free from the other, but sometimes gas has been found that had no apparent connection with petroleum. The connection, however, exists, and if the dryest gas could be followed throughout its underground reservoirs, it is altogether probable that accumulations of oil would be found.

Petroleum and natural gas are derived from the organic world. Both vegetable and animal substances are sources of supply for these products. The petroleum and gas that are found in the shales and sandstones are

in the main derived from vegetable matter, and as a large amount of the stocks, especially of petroleum, are found in the sandstones, vegetable matter may be said to be the chief source. As the limestones themselves are known to be a product of animal life, it is fair to presume that the oil and gas contained therein are derived from animal matter. The vegetable and animal life represented in oil and gas are of the lower orders. Sea-weeds and other allied groups, and the lower groups of marine animals being altogether the most conspicuous elements. Destructive distillation has been given as an answer to the question: "How were petroleum and gas formed out of organic matter?"

Destructive distillation is defined as the decomposition of animal and vegetable matter at high temperatures in the absence of air. By this process gaseous and semi-liquid products are evolved, and a coke or carbon residue remains behind.

If shales, sandstones or limestones holding large quantities of organic matter, as they often do, and which buried at a considerable depth, should be subjected to a range of temperature, the lower limit of which may not exceed 400° or 500° Fahrenheit, there is no reason to doubt that petroleum and gas would result from this action. This is no doubt true in volcanic regions. Petroleum and gas, on a large scale, are not the products of destructive distillation, for the reason that all the regions of great petroleum and gas productions are remarkably free from all igneous intrusions and from all signs of excessive or abnormal temperatures. The condition of the rocks in which these products are found emphatically disproves this theory. Another theory given to account for the formation of petroleum and gas out of organic substances is called "spontaneous distillation at low temperatures." By low temperatures, ordinary temperatures are meant. It is only necessary, in order to disprove this theory, to state that destructive distillation is the only process known to science, under the name of distillation, which can account for the origin of oil or gas, and this does not go on at ordinary or low temperatures. A process that goes on at ordinary temperatures may be a chemical decomposition, but is certainly not a destructive distillation.

The "spontaneous distillation" theory has probably some apparent support in the fact that, where petroleum is stored in a rock, gas may be constantly escaping from it. The oil may be part of a primitive store, slowly escaping, and the gas may be constantly derived from the partial breaking up of the oil that is held in the shales. The term "spontaneous distillation" might apply to this stage, but it has nothing to do with the origin of either substance.

I think it can be safely claimed, and, in fact, all geologists and most chemists agree that these substances result from the primary chemical decomposition of organic substances buried with the forming rocks, and that they are retained as petroleum in the rocks from the date of their

formation. This petroleum is considered the original form, and is supposed to have volatilized in porous strata, liberating gas and leaving a heavy residue behind.

While our knowledge of the formation of petroleum and natural gas is still incomplete and inadequate, the following statements, made in regard to it by Professor Orton, are offered as embodying the most probable view:

1. Petroleum is derived from vegetable and animal substances that were deposited in and associated with the forming rocks.

2. Petroleum is not in any sense a product of destructive distillation, but is the result of a peculiar chemical decomposition by which the organic matter passes at once into this or allied products. It is the result of the primary decomposition of organic matter.

3. The organic matter still contained in the rocks can be converted into gas and oil by destructive distillation, but, so far as we know, in no other way. It is not capable of furnishing any new supply of petroleum under normal conditions.

4. Petroleum is, in the main, contemporaneous with the rocks that contain it. It was formed at or about the time that these stratas were deposited.

As petroleum and natural gas is found stored, and had its origin in stratified or sedimentary rocks, the question might be asked, Why is it not found in all localities where these rocks occur? For answer it may be said that over many areas where organic matter was deposited in large quantities the conditions were such that immediate decomposition took place and the oil and gas escaped into the air instead of being imprisoned in the porous reservoirs of the rocks. Second, in many large areas where these products were generated, probably in immense quantities, subsequent disturbances fractured and fissured the rocks in such a manner as to allow the stored oil and gas to escape. In other places large areas covered by the ancient ocean were almost barren of organic life, just as we now find portions of existing seas destitute of life, consequently these are naturally destitute of oil and gas in paying quantities.

COMPOSITION OF NATURAL GAS.

Rock gas, or, as it is now generally recognized, natural gas, has long been technically known as a light carburetted hydrogen. In composition it closely approaches the inflammable marsh gas that may be frequently seen bubbling from the muddy bottoms of stagnant pools or sluggish streams. Its composition is as follows, as indicated by the mean result of the analysis of four specimens from Indiana and three from Ohio, made by Professor C. C. Howard, for the United States Geological Survey:

Marsh gas	93.36
Nitrogen	3.28
Hydrogen	1.76
Carbon monoxide	0.53
Oxygen	0.29
Olefiant gas	0.28
Carbon dioxide	0.25
Hydrogen sulphide	0.18
Total	99.93

Marsh gas, the principal constituent of natural gas, is a simple compound of carbon and hydrogen in the proportion of 75 per cent. of the former to 25 per cent. of the latter, the chemical formula being C. H. 4. It is one of a large number of carbon compounds running through petroleum, asphaltum, coal, jet and graphite or plumbago, and ending with the diamond.

The following are the lighter hydrocarbon compounds which constitute the bitumen series, and are given in the order of their weight :

1. Gaseous—Marsh gas, rock gas, etc.
2. Volatile (or semi-gaseous)—Naphtha.
3. Fluid—Petroleum.
4. Semi-fluid—Maltha (or natural tar).
5. Solid—Asphaltum, geocerite, etc.
6. Rigid and brittle "asphaltum glance," albertite, etc.

From the above it may be seen that natural gas is simply the lightest known member of the bitumen family, which is itself the lighter part of the unstable hydrocarbon series. The several bitumens are so closely related that it is impossible to discuss the distribution or origin of any without considering the like attributes of all.

COMPOSITION OF TRENTON LIMESTONE GAS.

The following analyses were published by Professor Orton, but for the information of those to whom Orton's publications are inaccessible, they are reprinted in the following table :

DESCRIPTION.	OHIO.			INDIANA.			
	Fostoria.	Findlay.	St. Marys.	Muncie.	Anderson.	Kokomo.	Marion.
Hydrogen	1.89	1.64	1.94	2.35	1.86	1.42	1.20
Marsh gas	92.84	93.35	93.85	92.67	93.07	94.16	93.57
Olefiant gas . . . . .	.30	.35	.20	.25	.47	.30	.15
Carbon monoxide . . . . .	.55	.41	.44	.45	.73	.55	.60
Carbon dioxide . . . . .	.20	.25	.23	.25	.26	.29	.30
Oxygen . . . . .	.35	.30	.35	.35	.42	.30	.55
Nitrogen	3.82	3.41	2.98	3.53	3.02	2.80	3.42
Hydrogen sulphide . . . . .	.15	.20	.21	.15	.15	.18	.20

NOTE.—The Muncie gas was taken from wells Nos. 1, 2, 3, 4 and 6; the Anderson gas from the McCullough; the Kokomo gas from wells Nos. 1 and 2, and the Marion gas from well No. 3.

WASTE OF GAS IN DOMESTIC CONSUMPTION.

That there is an immense waste of gas by the domestic consumers is a fact that is patent to the most superficial observer. Natural gas, like any other fuel, requires a certain amount of air, or rather the oxygen that is contained in the air, in order to have a perfect combustion. Without the perfect combustion the value of the fuel, in the production of heat, is largely diminished. The blacksmith at his forge requires an intense heat in order to get the iron and steel that he works into the proper condition. In order to do this and, at the same time economize his coal, he uses his bellows, getting as great an admixture of air with his fuel as is possible. By so doing, he obtains the desired results as to heat and saves money in the economy of his fuel. In other words by his methods he obtains the greatest amount of heat from a given amount of fuel. That this result is not obtained, and that an enormous waste is practiced in the domestic consumption of gas, is due to the inefficient appliances in use. With the mixers now in use a pressure of from six to ten ounces in the lower pressure mains furnish as much, if not more, gas than can be perfectly consumed, though many of the smaller towns, as well as some of larger growth, are carrying from three to five pounds. The result is that the gas passes through the stoves and grates and is only partially consumed. This high pressure is not only unnecessary, but wasteful and dangerous.

The following table is given to show the amounts of gas that is consumed through different sized mixers and at different pressures. The tests which produced these results were made with a Westinghaus meter, and may be relied upon as correct:

CUBIC FEET OF GAS BURNED IN ONE HOUR.

PRESSURE.	SIZE OF MIXER.			
	No. 3. $\frac{3}{8}$ -inch.	No. 5. $\frac{1}{2}$ -inch.	No. 7. $\frac{5}{8}$ -inch.	No. 9. $\frac{7}{8}$ -inch.
$\frac{3}{16}$ -inch	36	66	96	156
$\frac{1}{8}$ -inch	41	76	108	164
$\frac{1}{4}$ -inch	45	84	116	178
$\frac{3}{8}$ -inch	48	96	134	196
$\frac{1}{2}$ -inch	55	100	144	208
$\frac{3}{4}$ -inch	60	108	156	228
$\frac{15}{16}$ -inch	64	114	168	240
1-inch	68	120	179	256

The fractions of an inch given in the size of the mixers denote the diameter of the orifice through which the gas passes at the point of admixture with the air.

It will be seen from the above table that the greater the pressure in any size mixer, the greater number of cubic feet of gas is consumed with only a fixed amount of air. It follows, then, that the higher the pressure the greater the amount of gas that passes through the mixer, and the more imperfect is the combustion. It is wasteful, as I have shown above, and it is dangerous from the fact that this half burned gas is liable to escape into houses and occasion suffocations or explosions. Consumers have been slow to adopt improved mixers and burners. This is largely owing to the method of paying for the gas by the month or year, instead of by meter measure. If the latter method had been the rule, consumers would have found it to their interest to adopt the improved methods of using this valuable fuel and would have economized its use in every way possible. To the present method of selling gas may be charged a very large amount of the extravagance and waste that has been practiced, and until the method is changed and this fuel is sold by meter measurement, I can see but little hope for economy in its use. The waste will continue and the end will be correspondingly hastened.

It has been shown that petroleum and gas have their origin in the organic substances that were imprisoned in the sedimentary rocks at the time of their formation. They are the products of the chemical decomposition of the animal and vegetable matter deposited in the sand and mud beds of the ancient oceans under the conditions that prevailed at that period. As these substances were limited in their extent, and in some localities the conditions favorable to the generation of oil and gas did not exist, hence it must logically follow that these products must be limited in amount. In other words, it may be said that at the beginning of the development of these valuable fluids a certain amount existed within the reservoirs of oil and gas bearing rocks. Also that the generation of these products in commercial quantities, if indeed any at all, has ceased many ages ago. Now if this be true, and it has been amply proven, then we may calculate that the time is fast approaching when the entire quantity will be exhausted. Turn whatever way we may in our explorations and theorizings, this fact stares us in the face. Within the fields of Indiana, as well as in the rich areas of other States, this end has been hastened and brought in sight all too soon by the reckless extravagance and waste that has been practiced. Within the Indiana field, alone, during the first years of gas developments, it can be shown that 100,000,000 cubic feet of this inestimable fuel was wasted every day. At the low prices that have obtained in this area, the waste to the present time would amount to upwards of twenty millions of dollars. The waste has been criminal, and the day of repentance is fast approaching, and can only be delayed by practicing the most rigid economy and unrelaxed efforts in the husbandry of this valuable resource of our State.

Final exhaustion is inevitable, and the time has been hastened by the

reckless folly of the consumers. However, I am glad to note that the people who are most deeply interested in the preservation of this valuable fuel are awakening to their true interest. An earnest and united effort is now being put forth by the gas companies of the State looking to its preservation. Upon the success of these efforts depends the lengthening of the time of the prosperity that has prevailed in this favored area of Indiana since the discovery of natural gas.